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Indian Standard

DENSITY OF HOT BRIQUETTED IRON (HBI) — METHOD FOR DETERMINATION

ICS 77.080

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

July 1999 **Price Group 2**

Sponge Iron and Smelting Reduction Sectional Committee, MTD 30

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards after the draft finalized by the Sponge Iron and Smelting Reduction Sectional Committee had been approved by the Metallurgical Engineering Division Council.

The production and use of Hot Briquetted Iron (HBI) is on the increase in India. HBI is an alternative feedstock to melting steel scrap for the production of steel. Keeping this in mind, the Sectional Committee has decided to formulate standards to evaluate important physical characteristics of HBI and this standard is one in the series to determine the following for hot briquetted iron (HBI):

i) Bulk density
ii) Effective density
iii) Apparent density
iv) Water absorption

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

AMENDMENT NO. 1 APRIL 2008
TO
IS 14719 : 1999 DENSITY OF HOT BRIQUETTED IRON (HBI) — METHOD FOR DETERMINATION

(*Page* 1, *clause* 2) — Substitute 'IS 460 : 1985' *for* 'IS 460 : 1962'.

(*Page* 3, *clause* 7.2.3, *line* 5) — Substitute 'retare' *for* 'retire'.

(MTD 30)

Reprography Unit, BIS, New Delhi, India

Indian Standard

DENSITY OF HOT BRIQUETTED IRON (HBI) — METHOD FOR DETERMINATION

1 SCOPE

This standard prescribes the method for determining:

a) bulk density or unit weight (in kg/m^3) of Hot briquetted Iron (HBI),

b) effective or Archimedes density (in kg/m^3) of HBI,

c) apparent density (kg/m^3) of HBI, and

d) water absorption (percent) by HBI.

2 REFERENCES

The Indian Standards listed below are necessary adjuncts to this standard:

IS No.	*Title*
460 : 1962	Specification for test sieves (revised in parts)
13905 : 1993	Hot briquetted sponge iron (HBI) for steel making

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply:

3.1 Open Pores — Cavities that are connected to the external surface of the particle either directly or via one another.

3.2 Closed Pores — Cavities that are closed off by surrounding solid and are inaccessible to the external surface.

3.3 Bulk Density — The weight in air, at a stated temperature, of a unit volume of a particular material including the voids within and between the particles, expressed in weight units per unit volume.

3.4 Effective Density — The mass of the material divided by the volume of the material, excluding the open but including the closed pores.

3.5 Apparent Density — The mass of the material divided by the volume of the material, including the open and closed pores.

3.6 True Density — The mass of the material divided by the volume of the material, excluding the open and closed pores

3.7 Water Absorption — The increase in mass of a sample due to the penetration of water into the open pores of the dry material. It is expressed as a percentage of the dry mass.

3.8 HBI means briquettes made out of sponge iron/ DRI produced in gas based direct reduction process at elevated temperature by the application of external pressure in a more or less closed mould.

4 SAMPLING

4.1 The sample size of hot briquetted iron for the purpose of conducting the bulk density test shall comprise of 100/120 briquettes, picked randomly from the lot received. Care shall be taken that 80 percent of the briquettes so selected are of full size. For other tests, one single piece of HBI is required to be selected for one set of tests. For repeat test a new piece would be needed. For reliable results five sets of tests need to be conducted, extreme results are to be discarded and mean of remaining three are to be reported.

4.2 The tests may be carried out using natural, air-dried, or oven-dried material. If the test is to be made on oven-dried material, the sample shall be dried at 105 ± 5°C for one hour and then cooled to ambient temperature. It is recommended that for tests other than bulk density test, oven-dried should always be used.

5 TEST APPARATUS

5.1 For Bulk Density Test

5.1.1 *Container*

The container for the sample shall be cylindrical having an internal diameter of 400 ± 2 mm and an internal height of 250 ± 2mm. The container shall be constructed of metal of sufficient thickness to ensure rigidity of the walls and base of the container under the conditions of the test. The container shall be reinforced by a steel band around the top and shall have four handles, separated by 90° attached to outer surface by welding.

5.1.2 Weighing scale with sensitivity 1 g.

5.1.3 *Sieves*

Sieves used shall be square mesh sieves conforming to IS 460.

5.1.4 *Drying Oven*

A suitably ventilated oven capable of temperature control at 105 ±5°C and of sufficient size to accommodate either the test sample or the moisture sample taken in accordance with Annex A of IS 13905.

5.1.5 *Equipment for Handling Sample*

For samples that are too heavy for manual handling, provision shall be made for mechanically raising and dropping the filled container. This equipment may consist of a small chain and pulley arrangement, a vibrating platform to which the container may be rigidly attached or any other suitable means.

5.2 For Other Tests

5.2.1 *Vessel*

Containing water and large enough to ensure that the suspended test piece (briquette) is completely submerged and does not touch the sides or bottom of the vessel.

5.2.2 *Balance*

Top loading, open, of adequate capacity (1 kg or more) with a sensitivity of 0.01 g. It shall be capable of having the vessel containing water to be placed on the weighing platform and tared and allowing the test piece to be suspended and weighed in water.

5.2.3 *Water*

Free from any impurity (for example dissolved air) that would significantly affect its density. In case of doubt, distilled water, or tap water that has been freshly boiled and cooled to room temperature shall be used.

5.2.4 *Cloth Towel*

To remove excess surface water.

5.2.5 *Suspension Wire*

Fine wire having a maximum diameter of 0.25 mm.

5.2.6 *Drying Oven*

A suitably ventilated oven capable of temperature control at 105 ±5°C and of sufficient size to accommodate either the test sample or the moisture sample taken in accordance with Annex A of IS 13905.

6 CALIBRATION OF CONTAINER FOR BULK

6.1 The volume of the container shall be calculated within a precision of 0.1 litre by the following procedure:

a) The weight of the distilled water required to fill the container shall be determined. The ambient temperature and pressure shall be recorded.

b) The weight obtained in (a) in grams shall be divided by the weight in grams of 1 litre of distilled water corrected to the same temperature and pressure.

c) The result of the calculation in (b) will be the volume of the container in litres.

7 TEST PROCEDURE

7.1 Procedure for Bulk Density Test

7.1.1 The dry container shall be weighed and the weight recorded to the nearest 0.1 kg.

7.1.2 *Loose Weight Determination*

7.1.2.1 The container shall be filled to overflowing by means of a shovel or scoop, the material being discharged from a height not exceeding 50 mm from the surface of the material inside the container. Care shall be taken to prevent obvious segregation of the particle sizes of which the sample is composed. The surface of the sample shall then be levelled off with a straight edge in such a way that any slight projections of the sample above the top edge of the container shall approximately balance the voids in the surface below the top of the container.

7.1.2.2 The filled container shall be transported to the weighing device without loss of material from the container. The net weight of the sample shall be determined by weighing to the 0.1 kg, the filled container and subtracting from this the tare weight of the empty container.

7.1.3 *Compact Weight Determination*

The container shall be filled in three approximately equal layers. When the weight of the sample permits manual handling each layer shall be compacted by placing the container on a firm foundation such as a concrete floor and raising alternate sides of the container about 25 mm above the floor and allowing it to drop in such a manner as to hit the floor with sharp, slapping blow. By this procedure the sample particles will arrange themselves in a closely compacted mass. The material shall be compacted by raising and dropping the container 5 times. When the weight of the sample requires mechanical handling this raising and dropping of the container may be done by use of a small chain pulley set up. The surface of the compacted sample shall then be levelled off with a straight edge as in **7.1.2.1** and weighed as in **7.1.2.2** and the bulk density calculated as in **8.1**.

7.2 For Other Tests

7.2.1 *Determination of Mass of Dry Test Piece*

Dry the test piece at 105 ± 5°C to constant mass (this usually requires 1 hour), and weigh to the nearest 0.01 g (mass, m_1).

7.2.2 *Determination of Apparent Mass of Immersed Test Piece*

Suspend the dried test piece by a thin wire and lower it into the vessel containing water at room temperature. Completely submerge it in the water making sure that it hangs free and does not touch the sides or the bottom of the vessel. Allow the test piece to remain suspended until all air bubbling stops and the weight on the balance reaches a constant minimum (mass, m_2).

7.2.3 *Determination of Mass of Soaked Test Piece*

Remove the test piece from the water. Let it drain momentarily and then gently remove the excess water with a wet towel that has been immersed in water and lightly wrung out by hand before each use. Immediately retire the balance to zero and resuspend the test piece as before. Immediately determine the mass of the soaked piece (mass, m_3).

8 CALCULATION

8.1 For Bulk Density

The bulk density or unit weight of the sample shall be calculated as follows:

$$\text{Bulk density (kg/m}^3) = (W/V) \times 1\ 000$$

where

W = mean of three successive determinations of net weight of the sample in kg of filled container, and

V = volume of container in litres as calculated in **6.1**.

8.2 For Other Tests

The formulae for different type of densities are given as under.

8.2.1 *Effective Density (Archimedes Density)*

$$P_e = \frac{m_1}{(m_1 - m_2)}$$

8.2.2 *Apparent Density*

$$P_a = \frac{m_1}{(m_3 - m_2)}$$

NOTE — A typical procedure for determining the apparent density is given in Annex A.

8.2.3 The water absorption expressed as a percentage of the dry mass :

$$a = \left(\frac{m_3 - m_2}{m_1} \right) \times 100$$

where

m_1 = mass, in grams, of the dried test piece determined by weighing in air;

m_2 = apparent mass, in grams, of the immersed test piece;

m_3 = mass, in grams, of the soaked test piece.

Report the density results rounded to the nearest 0.1 kg/m^3 and the water absorption to the nearest 0.1 percent.

NOTES

1 In the above calculation density of water has been assumed as 1 000 kg/m^3. If higher precision is needed, or a different unit is used, terms in **8.2.1** and **8.2.2** need to be multiplied by the density of water.

2 For determination of densities the results of duplicate determinations carried out by the same operator with the same apparatus on the samples from the same consignment and taken in succession shall not differ by more than 0.1 tonne/m^3.

9 TEST REPORT

The test report shall include the following:

a) A statement of the condition of the 'as tested' sample, natural, air-dried or oven-dried;

b) The measured values of all tests and their mean value;

c) For bulk density determination the date of calibration of the container according to **6.1**;

d) Kind and temperature of water and time of immersion in water for other tests;

e) Statement of the weighing devices used;

f) The percent moisture content of sample if desired by customer; and

g) A sieve analysis showing percent on each sieve and percent cumulative.

ANNEX A

(*Clause* 8.2.2)

DETERMINATION OF APPARENT DENSITY OF HBI

A-1 OUTLINE

Following outlines the laboratory procedure for determining briquette (HBI) density using an individual whole briquette.

Apparatus:

Plastic Beaker	: Capacity, 2 000 ml
Graduated Measuring Cylinder (polypropyline)	: 1 000 ml capacity
Graduated measuring	: 200 ml capacity cylinder with graduation 1 ml minimum
Volumetric flask	: 1 000 ml capacity
Weighing scale	: 2-3 kg capacity with 0.1 g accuracy

Apparent density is the ratio of weight of the dried briquette and its apparent volume.

$$\text{Apparent Density (g/cc)} : \frac{\text{(Weight of the dried briquette in g)}}{\text{Apparent volume of the briquette (cc)}}$$

A-2 DETERMINATION OF APPARENT VOLUME

Weigh a dried whole briquette to an accuracy of 0.1 g (say 'A' g). Place the weighed briquette into a clean 2 000 ml capacity beaker. Pour water into the beaker so that the briquette is completely submerged in the water and putting some excess water so that the total water in the beaker is about 1 500 ml. Allow the submerged briquette to remain in the water until all the pores of the briquette are filled with water. This can be visually seen when the air bubbles no longer appear on the briquettes surface upon tapping the beaker gently.

Carefully remove the briquette from the water, leaving the remaining water in the beaker. This water should be transferred into a 1 000 ml volumetric flask filling exactly up to the mark.

Lightly dry only the surface of the briquette with a blotting or absorbent paper. Do not attempt complete dryness and immediately put the briquette into the 1 000 ml graduated cylinder. Transfer water from the volumetric flask into the graduated cylinder containing the briquette, filling it exactly up to the 1 000 ml mark. Transfer the left out water of the volumetric flask into a dry and clean 200 ml measuring cylinder and note down the volume of water (say 'V' ml).

A-3 CALCULATION

$$\text{Apparent density of HBI} = \frac{A}{V}\ \text{g/cc}$$

A-4 WATER ABSORPTION

The HBI kept in the 1 000 ml graduated cylinder in the previous experiment of apparent density is taken out from the cylinder and its surface water is dried with blotting paper or any absorbent paper and its weight is noted (say 'B' g). Do not wait for the stable weight as the weight of the briquette may go on decreasing due to evaporation.

$$\text{Percent of water absorption} = \frac{(B-A)\times 100}{A}$$

where A is the weight in g of dry HBI.

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